Work

- Whenever a force moves a distance
- $W = F \Delta x \cos\theta$
  - F: force (N)
  - $\Delta x$ : displacement (m)
  - $\theta$: angle between force & displacement (usually $0^o$)
- SI Unit: Joule ($1J=kg\ m^2/s^2$)
- If you hold a 100 kg mass above your head for an hour, you didn't do any work. Why not?
- Forces perpendicular to displacement do no work.
- The area under a force *vs* displacement graph gives the work done by the force in performing the displacement.

***Problem: Work (B-1988)***

6. A horizontal force F is used to pull a 5-kilogran block across a floor at a constant speed of 3 meters per second. The frictional force between the block and the floor is 10 newtons. The work done by the force F in 1 minute is most nearly

(A) 0 J (B) 30 J (C) 600 J
(D) 1,350 J (E) 1,800 J

**Show your WORK:**

Kinetic Energy

- Energy due to motion
- Energy is a scalar
- $KE = \frac{1}{2} m v^2$
  - K: Kinetic Energy in Joules.
  - m: mass in kg
  - v: speed in m/s
- SI Units: Joules

The Work-Kinetic Energy Theorem

- $W_{net} = \Delta KE$
- Net work is used in this theorem. This is work due to ALL FORCES acting upon object (or the net force).
- When net work is positive, the kinetic energy of the object will increase (it will speed up).
- When net work is negative, the kinetic energy of the object will decrease (it will slow down).
- When there is no net work, the kinetic energy is unchanged (constant speed).

***Problem: Work-Kinetic Energy (Princeton review)***

1. Under the influence of a force, an object of mass 4 kg accelerates from 3 m/s to 6 m/s in 8 seconds. How much work was done on the object during this time?
a. 27 Joules.
b. 54 Joules.
c. 72 Joules.
d. 96 Joules.
e. Cannot be determined from the information given.

**Show your work:**

Power

- The *rate* of which work is done.
- $P = W/t$
  - work/time
- $P = F V$
  - (force )(velocity)
- SI unit for Power is the Watt.
- 1 Watt = 1 Joule/s

***Problem: Power (B-1998)***

9. A child pushes horizontally on a box of mass *m* which moves with constant speed $\upsilon$ across a horizontal floor. The coefficient of friction between the box and the floor is $\mu$. At what rate does the child do work on the box?
(A) $\mu m g \upsilon$
(B) $m g \upsilon$
(C) $\upsilon/\mu m g$
(D) $\mu m g/\upsilon$
(E) $\mu m \upsilon^2$

**Show your work:**

How We Buy Energy…

- The kilowatt-hour is a commonly used unit by the electrical power company.
- Power companies charge you by the kilowatt-hour (kWh), but this not power, it is really energy consumed.
- 1 kW = 1000 W
- 1 h = 3600 s
- $1\ kWh = 1000J/s \bullet 3600s = 3.6 \times 10^6 J$

Gravitational Potential energy

- Stored energy an object possesses by virtue of its height
- $PE_g = mgh$
  - m: mass of object (kg)
  - g: acceleration due to gravity ($m/s^2$)
  - h: height change (m) (positive to go up)
- We can choose where to set the zero, but often we set it at the surface of the Earth.

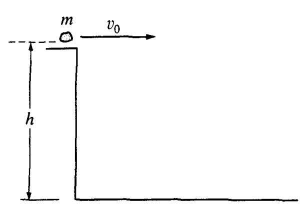
Elastic potential energy

- Springs also can possess potential energy
- $PE_e = \frac{1}{2} kx^2$
  - k: force constant of a spring (N/m).
  - x: the amount the spring has been stretched or compressed from its equilibrium position (m).
- A spring has no stored energy when in equilibrium, where the spring is neither compressed or extended.

Law of Conservation of Mechanical Energy

- $PE_i + KE_i = PE_f + KE_f$
- If all the forces are conservative (friction or air resistance are NON conservative) mechanical energy is conserved.

***Problem: Conservation of Energy (B-1998)***




A rock of mass *m* is thrown horizontally off a building from a height *h,* as shown above. The speed of the rock as it leaves the thrower's hand at the edge of the building is $\upsilon_0$ .

59. What is the kinetic energy of the rock just before it hits the ground?

(A) $mgh$ (B) $\frac{1}{2}m\upsilon_0^2$ (C) $\frac{1}{2}m\upsilon_0^2 - mgh$

(D) $\frac{1}{2}m\upsilon_0^2 + mgh$ (E) $mgh - \frac{1}{2}m\upsilon_0^2$

**Show your work:**

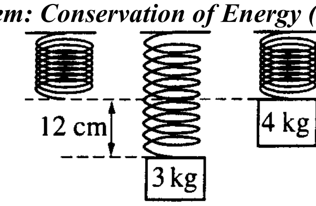
***Problem: Conservation of Energy (B-1993)***

47. A block of mass m slides on a horizontal frictionless table with an initial speed $v_0$ . It then compresses a spring of force constant k and is brought to rest. How much is the spring compressed from its natural length?

(A) $\frac{v_0^2}{2g}$ (B) $\frac{mg}{k}$ (C) $\frac{m}{k}v_0$ (D) $\sqrt{\frac{m}{k}}v_0$ (E) $\sqrt{\frac{k}{m}}v_0$

**Show your work:**

***Problem: Conservation of Energy (B-1998)***




38. A block of mass 3.0 kg is hung from a spring, causing it to stretch 12 cm at equilibrium, as shown above. The 3.0 kg block is then replaced by a 4.0 kg block, and the new block is released from the position shown above, at which the spring is unstretched. How far will the 4.0 kg block fall before its direction is reversed?

(A) 9 cm
(B) 18 cm
(C) 24 cm
(D) 32 cm
(E) 48 cm

**Show your work:**